

I. Amendments to the Specification

Please replace the Title with the following amended title:

CONTOUR CORRECTING VIDEO SIGNAL PROCESSING APPARATUS

Please replace the paragraph beginning on page 29, line 10 with the following amended paragraph:

The edge generation means 3 generates the edge signal S_E using the edge period of the digital video signal S_1 detected by the edge detection means [[7]] 2 and the edge coefficient K supplied from an interpolation control means that is not illustrated.

Please replace the paragraph beginning on page 29, line 20 with the following amended paragraph:

The edge generation means 3 sequentially generates the samples B' , C' , D' , E' , F' corresponding to an edge period detected by the edge detection means [[7]] 2, for example, the samples B , C , D , E , F of the digital video signal S_1 . Supposing that the first sample B' of the edge period is the first sample and the j -th (where, $j = 1, 2, 3, 4, 5$) sample signal level is V_j , it follows that

$$V_j = B + \beta_j \times (F - B) \quad \text{..... (1)}$$

Please replace the paragraphs beginning on page 38, line 2 through page 40, line 11 with the following amended paragraphs:

In Fig. 11, an electric signal obtained by the photographing of the imaging means [[1]] 101 is supplied to the signal processing means [[2]] 201 and the digital video signal S_1 of the

sample (pixel) cycle t is generated. This digital video signal S_1 is written to the memory means [3] 301 at the timing of the sample cycle t every sample with the write timing pulse P_w generated by the interpolation control means [4] 401, and a sample is sequentially read with the read timing pulse P_R generated by the interpolation control means [4] 401 in the four-time timing of the sample cycle t . Moreover, the sample is read by $1H$ every $4H$ (H is a horizontal scanning period) in a vertical scanning direction. Accordingly, the one fourth portion of the sample is sampled with the digital video signal S_1 input to the memory means [3] 301. Consequently, the digital video signal S_2 of a picture (hereinafter referred to as an enlarged picture) enlarged into four times in horizontal/vertical scanning directions respectively is obtained.

As shown in Fig. 12, the [The] interpolation means [5, 6] 501, 601, the selection means [10] 5, and the interpolation control means [4] 401 constructs an interpolation device. The digital video signal S_2 is supplied to the interpolation means [5, 6] 501, 601 of this interpolation device. The interpolation means [6] 601 consists of the edge detection means [7] 2, the edge generation means [8] 3, and the mixing means [9] 4. In the interpolation means [5] 501, a digital video signal of the sample cycle T is interpolated linearly (also in a vertical scanning direction, the linear interpolation of a horizontal scanning line is performed, but the linear interpolation in the vertical scanning direction is not described) using the interpolation coefficient K_1 generated by the interpolation control means [4] 401, and a digital video signal S_3 of the sample cycle t is obtained. This digital video signal S_3 is supplied to the selection means [10] 5 and the mixing means [6] 4 of the interpolation means [6] 601.

On the other hand, in the interpolation means [6] 601, when the edge detection means [7] 2 detects the edge of the digital video signal S_2 of an enlarged picture by the method

described later, the edge generation means [[8]] 3 generates an edge signal S_E consisting of the sample of the cycle t using the digital video signal S_2 and the edge coefficient K_2 described later generated by the interpolation control means [[4]] 401 based on the detection result. This edge signal S_E is supplied to the mixing means [[9]] 4 and mixed with the digital video signal S_3 output from the interpolation means [[5]] 501. The edge generation means [[8]] 3 and the mixing means [[9]] 4 forms an edge enhancement means in this manner that enhances the edge of the digital video signal S_3 interpolated from the interpolation means [[5]] 501.

A digital video signal S_4 with which the edge signal S_E output from this mixing means [[9]] 4 is mixed is supplied to the selection means [[10]] 5 as an output signal of the interpolation means [[6]] 601. This selection means [[10]] 5 is controlled using a selection control signal S_5 in the period of this edge generated when the edge detection means [[7]] 2 detected the edge of the digital video signal S_2 , and selects, in the edge period, the output digital video signal S_4 of the interpolation means [[6]] 601, and, in a period other than the edge period, the output digital video signal S_3 of the interpolation means [[5]] 501. Accordingly, the output digital video signal S_3 of the interpolation means [[5]] 501 is obtained in an output terminal 11 in the edge period by interpolating the output digital video signal S_4 of the interpolation means [[6]] 601.

In the interpolation means [[5]] 501, the digital video signal S_2 is interpolated using the linear interpolation described in Fig. 12, but this linear interpolation is described with reference to Figs. 12 (b), (c).

Please replace the paragraphs beginning on page 41, lines 6 through 17 with the following amended paragraphs:

The interpolation means [[5]] 501 generates the interpolation sample $Q1$ by supplying

$$(4 - i) / 4 \text{ and } i / 4$$

in the aforementioned expression (1) from the interpolation control means [[4]] 401 as the interpolation coefficient K_1 and performing the operation of the aforementioned expression (1) every adjacent two samples in the picture P_2 shown in Fig. 12 (b), and generates the picture P_3 shown in Fig. 12 (c) interpolated using this sample. The signal of this picture P_3 is the digital video signal S_3 in Fig. 1.

Subsequently, the operation of the edge detection means [[7]] 2 is described with reference to Figs. 13 to 16.

Please replace the paragraphs beginning on page 42, lines 6 through 22 with the following amended paragraphs:

The edge detection operation of the edge detection means [[7]] 2 is described below citing one specific example of an image pattern.

(1) As a first edge criterion of the edge judgment of the edge detection means [[7]] 2, two flat portions that differ in a signal level are detected in the aforementioned judgment sample period. When no flat portion can be found between these flat portions, an edge is assumed to exist between these flat portions.

Fig. 14 shows one specific example of the judgment sample period in which an edge can be judged based on this first edge criterion, and Fig. 14 (b) is the digital video signal S_2 of the sample cycle T input to the edge detection means [[7]] 2. Fig. 14 (a) conveniently shows an example of the continuous waveform of this digital video signal S_2 . This digital video signal S_2 samples the video signal shown in this Fig. 14 (a) in the sample cycle T.

Please replace the paragraph beginning on page 43, line 3 with the following amended paragraph:

For these judgment sample periods A to E, the edge detection means [[7]] 2, first, obtains the absolute value $|A - B|$ of the difference of the signal levels of the first two samples A, B. When this value is lower than the threshold DELTA 1 ("Yes" in Step 100 of Fig. 13), a flat portion is assumed to exist between the samples A and B. Subsequently, the absolute value $|B - C|$ of the difference of the signal levels of the samples B, C is obtained. When this value is lower than the threshold DELTA 1 ("Yes" in Step 101 of Fig. 13), the flat portion of the period of $2T$ is obtained, and, accordingly, an edge is assumed to be undetected (Step 301 of Fig. 13). The processing of this judgment sample period terminates and the same judgment processing starts in the next judgment sample period starting from the sample B shifting by the sample cycle T .

Please replace the paragraph beginning on page 46, line 12 with the following amended paragraph:

Fig. 15 shows one specific example of the judgment sample period in which an edge can be judged based on this second edge criterion, and, in this specific example, a flat portion and the crest of a peak are detected. Fig. 15 (b) is the digital video signal S_2 of the sample cycle T input to the edge detection means [[7]] 2. Fig. 15 (a) conveniently shows an example of the continuous waveform of this digital video signal S_2 , and, as illustrated, shows the start portion of a picture that represents a striped pattern in which light and shade are repeated every period of less than $2T$. The digital video signal S_2 samples the video signal shown in this Fig. 15 (a) at the same cycle T . Even in this specific example, the judgment sample period is specified as $4T$ and the samples to be judged are specified as the samples A to E.

Please replace the paragraphs beginning on page 48, line 19 through page 49, line 26 with the following amended paragraphs:

(3) As a third edge criterion of the edge judgment of the edge detection means $[[7]]$ 2, when the crest of a peak and the root of a valley are detected in the aforementioned judgment sample periods, an edge is assumed to exist between these crest of the peak and root of the valley.

Fig. 16 shows one specific example of the judgment sample period in which an edge can be judged based on this third edge criterion. In this specific example, the crest of a peak and the root of a valley are detected. Fig. 16 (b) is the digital video signal S_2 of the sample cycle T input to the edge detection means $[[7]]$ 2. Fig. 16 (a) conveniently shows the intermediate portion of an example of the continuous waveform of this digital video signal S_2 , and, as illustrated, shows a picture that represents a striped pattern in which light and shade are repeated every period of $2T$ or less. The digital video signal S_2 samples the video signal shown in this 16 (a) in the sample cycle T. Even in this specific example, the judgment sample period is specified for $4T$ and the samples to be judged are specified as the samples A to E.

In Fig. 16 (b), for these judgment sample periods A to E, the edge detection means $[[7]]$ 2, first, obtains the absolute value $|A - B|$ of the difference of the signal levels of the first two samples A, B. This is judged to be higher than the threshold DELTA 1 ("No" in Step 100 of Fig. 13) and higher than the threshold DELTA 2 ("Yes" in Step 111 of Fig. 13). Subsequently, the absolute value $|B - C|$ of the difference of the signal levels of the samples B, C is obtained and this value is judged to be higher than the threshold DELTA 1 ("No" in Step 112 of Fig. 13). Furthermore, when the absolute value $|B - C|$ is lower than the threshold DELTA 1 ("Yes" in Step 112 of Fig. 13), a flat portion is assumed to exist between the samples B and C.

Accordingly, an edge is assumed to be undetected (Step 303 of Fig. 13) and processing moves to the processing between the next judgment sample periods.

Please replace the paragraphs beginning on page 52, lines 9 through 17 with the following amended paragraphs:

Returning to Fig. 11, the edge detection means [[7]] 2 detects an edge of an input digital video signal S_2 from the memory 3 in this manner.

The edge generation means 3 of the interpolation means [[6]] 601 generates the edge signal S_E using the edge period of the digital video signal S_2 detected by the edge detection means [[7]] 2 and the edge coefficient K_2 supplied from the interpolation control means [[4]] 401. This is described with reference to Fig. 16.

Please replace the paragraphs beginning on page 52, lines 22 through page 56, line 3 with the following amended paragraphs:

Moreover, Fig. 17 (b) shows the edge portion of the digital video signal S_3 interpolated linearly by the interpolation means [[5]] 501 and the edge signal S_E generated by the edge generation means [[8]] 3 against this. Incidentally, black circles are the samples B, C, D, a circle is an interpolation sample interpolated linearly between the samples B and C and between the samples C and D, and a square is the sample of the edge signal S_E that forms an edge period generated by the edge generation means [[8]] 3.

The edge generation means [[8]] 3 sequentially generates seven edge interpolation samples (shown with a square in Fig. 17) in the sample cycle t ($= T/4$) in the edge period detected by the edge detection means [[7]] 2, for example, between the samples B and D of the

digital video signal S_2 . Supposing the j -th (where, $j = 1, 2, \dots, 7$) signal level is V_j , it follows that

$$V_j = B + \beta_j \times (D - B) \quad \dots\dots (2)$$

Where, B, D : Signal levels of samples B, D

$$0 \leq \beta_j \leq 1$$

The edge generation means [\[\[8\]\] 3](#) obtains a signal level

$$V_K = (B + D) / 2$$

assuming $\beta_j = 1/2$ in the above expression (2). Among the interpolation samples in the edge period of the digital video signal S_3 from the interpolation means [\[\[5\]\] 501](#), an interpolation sample of this signal level V_K is generated at the timing of the interpolation sample of the signal level most approximate to this signal level V_K . The signal levels V_1, V_4, \dots, V_{K-1} of all edge interpolation samples that precede this edge interpolation sample are specified as signal level B when $\beta_j = 0$ in the aforementioned expression (2) and the signal levels $V_{K+1}, V_{K+2}, \dots, V_7$ of all edge interpolation samples following this edge interpolation sample are specified as signal level D when $\beta_j = 1$ in the aforementioned expression (2).

Accordingly, supposing the edge interpolation sample of this signal level V_K is most approximate to the signal level of the sample C of the digital video signal S_2 , the efficient β_j of the signal level V_j in the aforementioned expression (2) of the edge interpolation sample in the edge period appears as

$$0, 0, 0, 1/2, 1, 1, 1$$

This coefficient β_j is supplied from the interpolation control means [\[\[4\]\] 401](#) as an edge coefficient K_2 .

Furthermore, this edge coefficient K_2 is not limited to only this, but it can be set optionally as occasions demand, such as

0, 0, 0, 1, 1, 1, 1

Or

0, 0, 1/3, 2/3, 1, 1, 1

Or

0, 0, 1/5, 1/2, 4/5, 1, 1

The edge signal S_E generated by the edge generation means [\[\[8\]\] 3](#) in this manner is supplied to the mixing means [\[\[9\]\] 4](#). This edge signal S_E and the digital video signal S_3 from the contour correction means 5 are mixed at a desired ratio and the digital video signal S_4 is generated.

Incidentally, the edge signal S_E generated in this manner can reproduce an edge component exceeding one half of the sampling frequency $1/T$ of the digital video signal S_2 according to a sampling theorem, but the reproduction is a forecast to the end. Accordingly, the image quality deterioration generated by an aliasing phenomenon when the forecast was not right can be reduced by mixing the output digital video signal S_3 of the interpolation means [\[\[5\]\] 501](#) interpolated according to the sampling theorem and the edge signal S_E output from the edge generation means [\[\[8\]\] 3](#).

The selection means [\[\[10\]\] 5](#) selects the digital video signal S_4 in the edge period (for example, the period between the samples B and D in Figs. 14 to 16) of the digital video signal S_3 controlled using the control signal S_8 from the edge detection means [\[\[7\]\] 2](#) and detected by the edge detection means [\[\[7\]\] 2](#), and selects the digital video signal S_3 from the interpolation means [\[\[5\]\] 501](#) in other periods.

As described above, in this embodiment, when a digital picture is enlarged, because the enlarged picture is interpolated using an edge signal represented in the frequency component exceeding one half of sampling frequency in only the portion in which there is the frequency component exceeding the half of the sampling frequency of the enlarged picture, a picture having high sharpness can be obtained.

Moreover, because the edge detection means $[[7]]$ 2 and the edge generation means $[[8]]$ 3 are constructed without a multiplication means, a circuit scale can be reduced small.

Furthermore, the aforementioned embodiment was described assuming it to apply to a camera device, but the invention is not limited to only this. Needless to say, the invention can be applied to another system, such as a sample is sampled and sent as a picture in which the number of samples was reduced on the sending side and the invention applies to the sample and the picture is interpolated on the receiving side.